# Predicting Phytoplankton Functional Types with Remote Sensing Data

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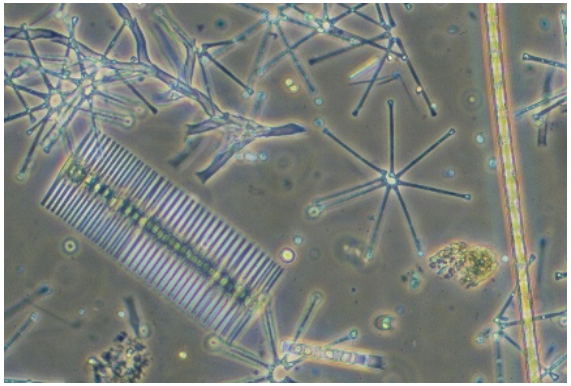
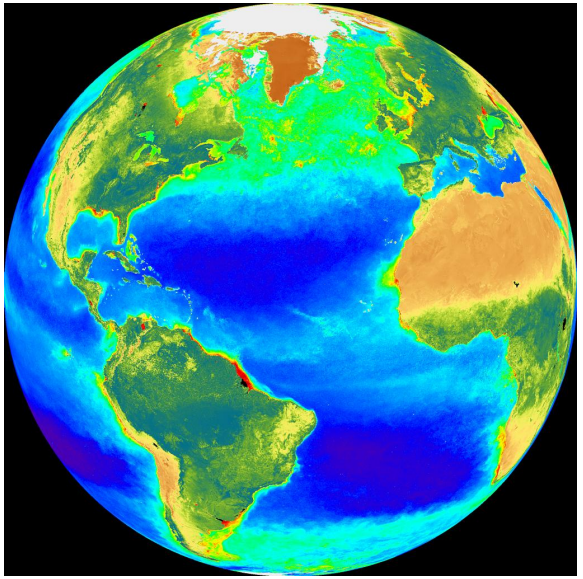
NESDIS STAR

8/27/15





# Ocean color approaches for discerning phytoplankton communities from remote sensing

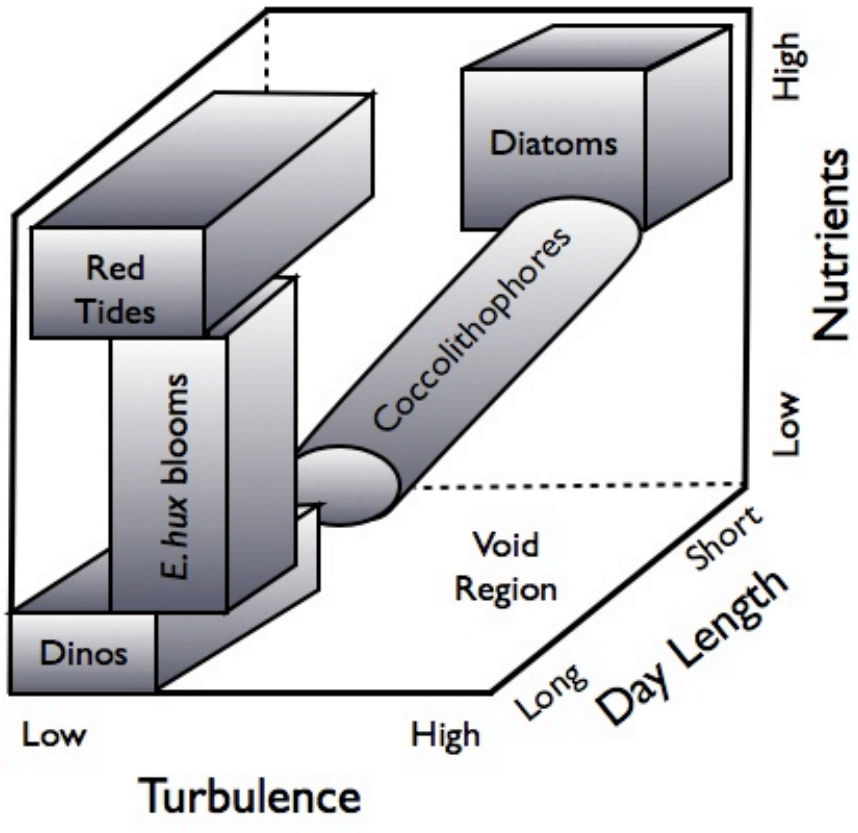
- *Functional type* (biogeochemical function)
  - Spectral approach – PHYSAT, PhytoDOAS
- *Phytoplankton size* (governs many traits)
  - Spectral approaches (absorption, backscattering properties)
  - Chlorophyll approaches

Table 1. Summary of the algorithms, contact person, PFT represented.

| Algorithm | Contact Person | PFTs | Methodology |
|---|---|---|---|
| Brewin et al. (2010) | R.J.W. Brewin | Micro, Nano, Pico | Abundance-based |
| Devred et al. (2006) | E. Devred | Micro, Nano+Pico | Abundance-based |
| OC-PFT | T.Hirata | Micro, Nano, Pico, Diatom, Haptophyte, Prokaryotes, Chlorophyte, Pico-Eukaryotes, Prochlorococcus | Abundance-based |
| Uitz et al. (2006) | J. Uitz | Micro, Nano, Pico | Abundance-based |
| PHYSAT | S. Alvain | Diatom, Nanoeukaryote, Prochlorococcus, Synechococcus-like, Phaeocystis | Optics-based |
| PhytoDOAS | A. Bracher | Diatom, Cocolithophore, Cyanobacteria | Optics-based |
| Ciotti and Bricaud (2002) | A. Bricaud | Micro, Pico | Optics-based |
| Fujiwara et al. (2011) | T. Hirawake | Micro, Nano, Pico | Optics-based |
| Kostadinov et al. (2009) | T. Kostadinov | Micro, Nano, Pico | Optics-based |
| Mouw et al. (2010) | C. Mouw | Micro, Pico | Optics-based |
| Roy et al (2012) | S. Roy | Micro, Nano, Pico | Optics-based |

http://pft.ees.hokudai.ac.jp/satellite/index.shtml

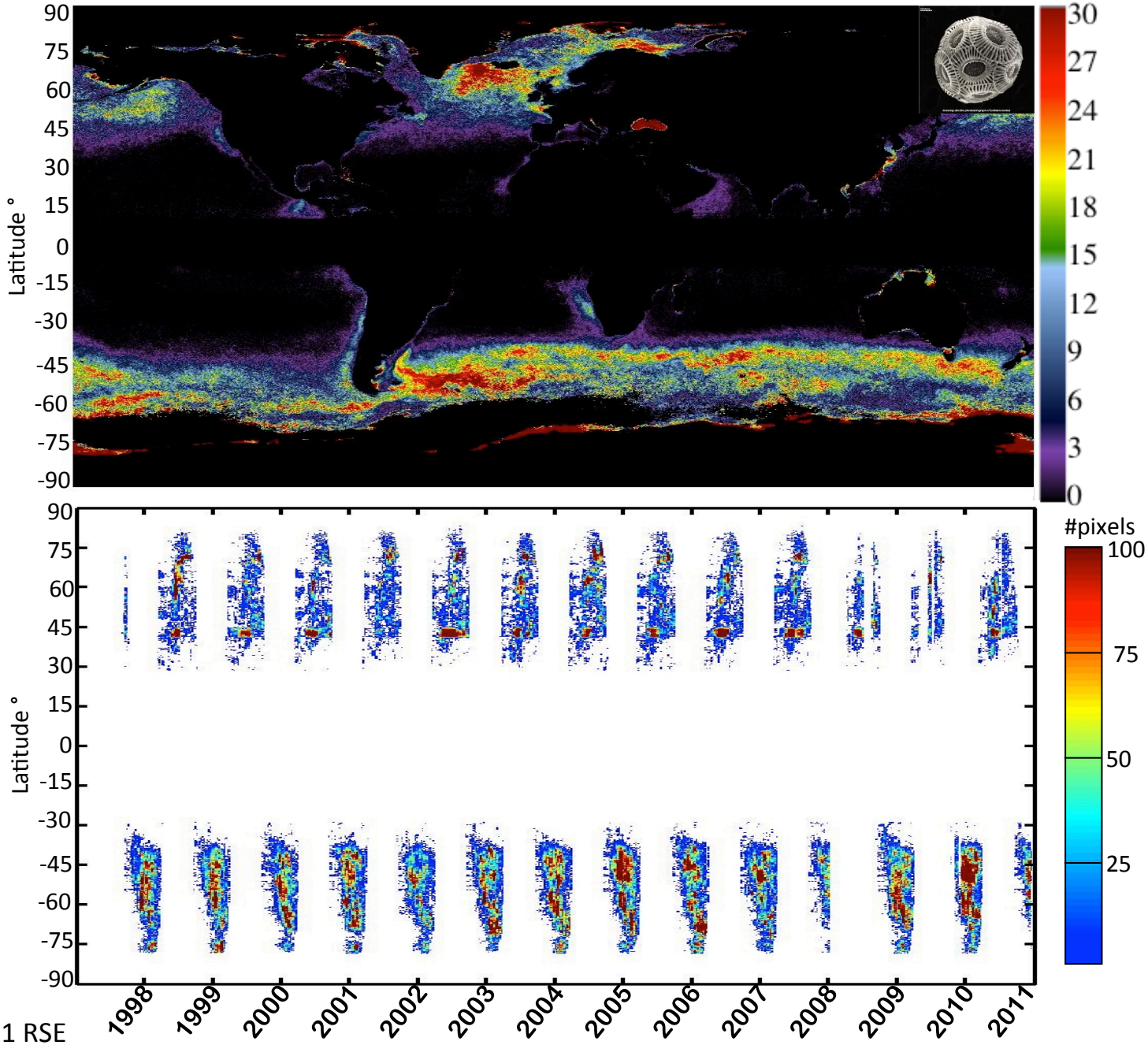
# Niche Concept




from Balch, 2004

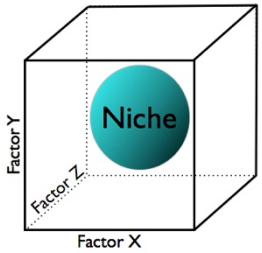
- Widely accepted that PFT groups have distinct biogeography.
- Margalef Mandala is a useful construct to understand phytoplankton distributions across a varied environmental landscape.
- Niche models widely used in ecology to describe *species* distributions.
- Statistical in nature, and depends on assumptions regarding species presence/ absence.

# SeaWiFS coccolithophore bloom patterns

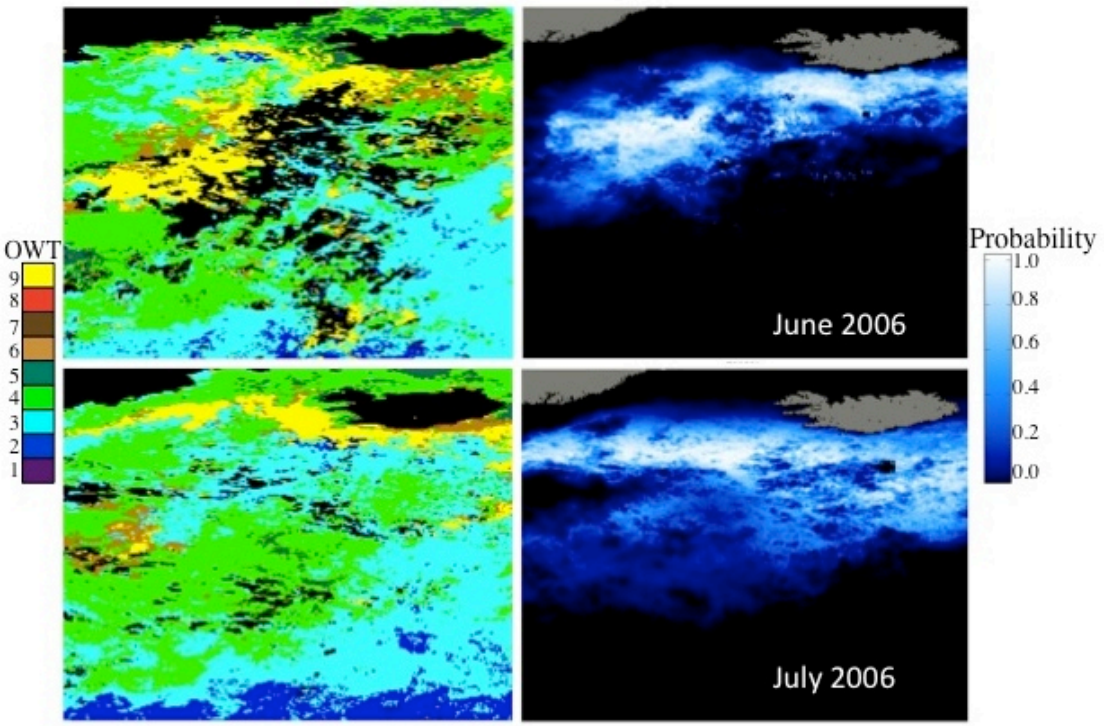


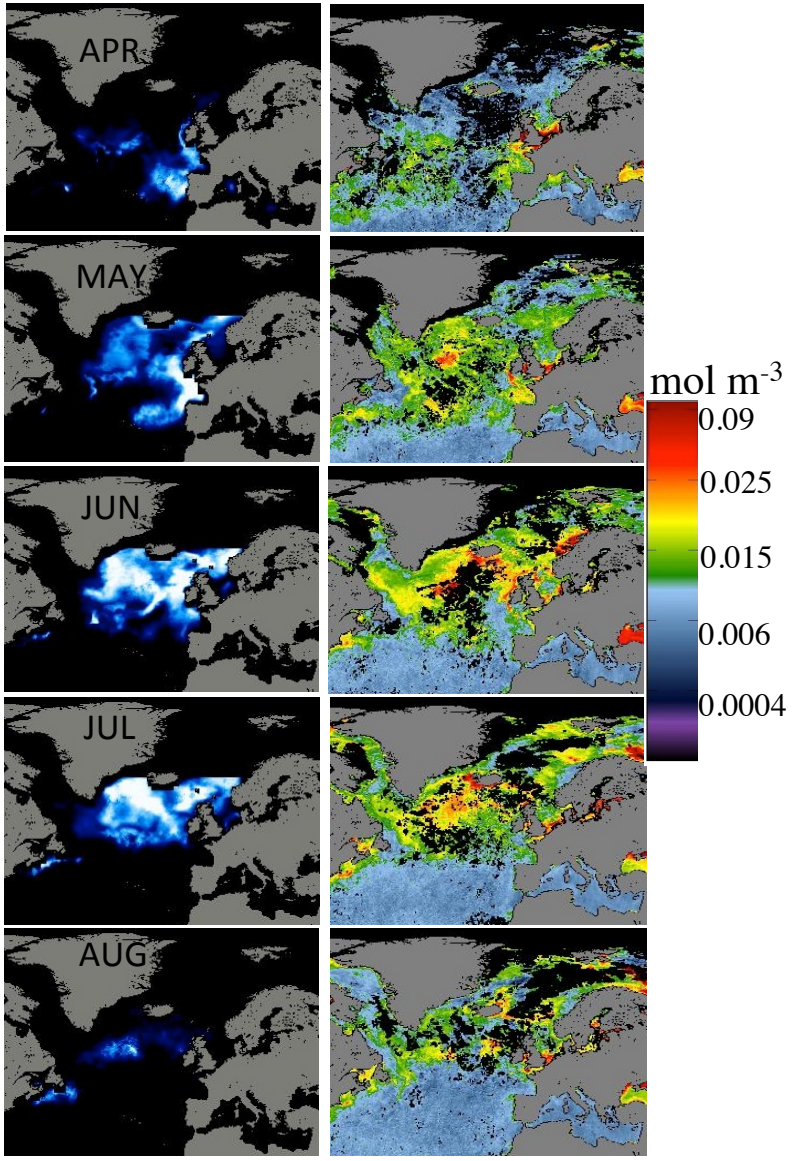

Moore et al, 2011 RSE

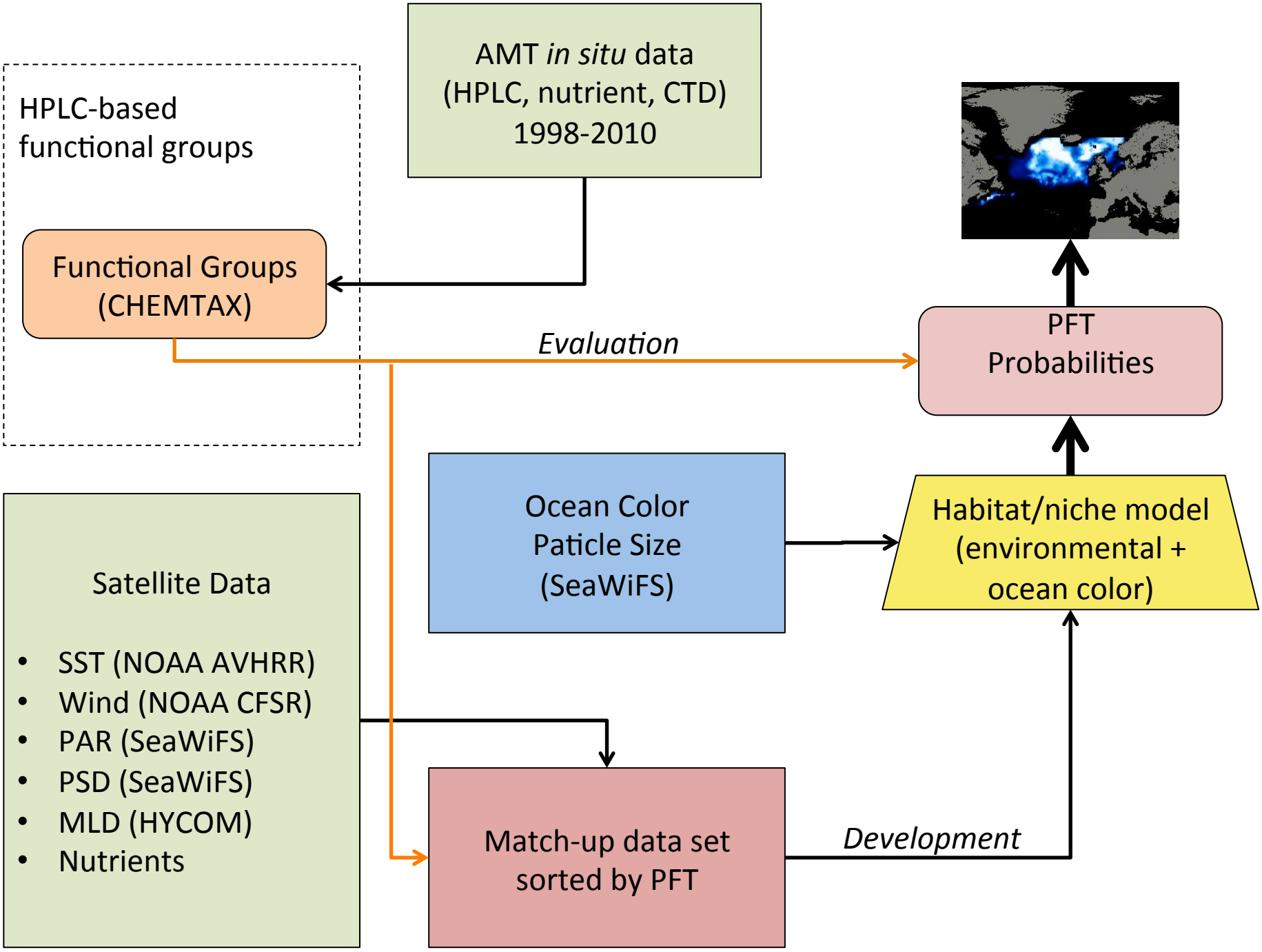
# A Coccolithophore ‘bloom’ niche model




- Using OC data, bloom pixels used as mask to select co-located environmental data
- Niche was characterized by statistical distribution of environmental data (SST, MLD, PAR, Winds).




AMT *in situ* data
(HPLC, nutrient, CTD)
1998-2010
HPLC-based
functional groups
Functional Groups
(CHEMTAX)
Evaluation
PFT
Probabilities
Ocean Color
Paticle Size
(SeaWiFS)
Habitat/niche model
(environmental +
ocean color)
Satellite Data
• SST (NOAA AVHRR)
• Wind (NOAA CFSR)
• PAR (SeaWiFS)
• PSD (SeaWiFS)
• MLD (HYCOM)
• Nutrients
Match-up data set
sorted by PFT
Development

# PFT Training Data Set

Atlantic Ocean
HPLC Data

AMT
SeaBASS
CLIVEC
Pangea

N ~ 2500

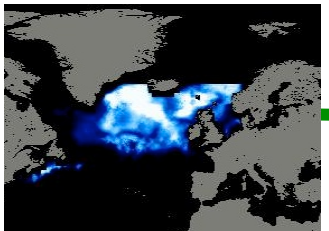
CHEMTAX
(based on 'known' pigment ratios)

% Phytoplankton of Chla

Diatoms
Dinoflagellates
Prochlorococcus
Prymensiophytes
Chlorophytes
Chrysophytes
Crytpophytes
Synechococcus
Prasinophytes

PFT groups

- 4 PFT groups created
- Dominant PFT identified as fraction of biomass > 0.45
- Coccolithophores added from existing model



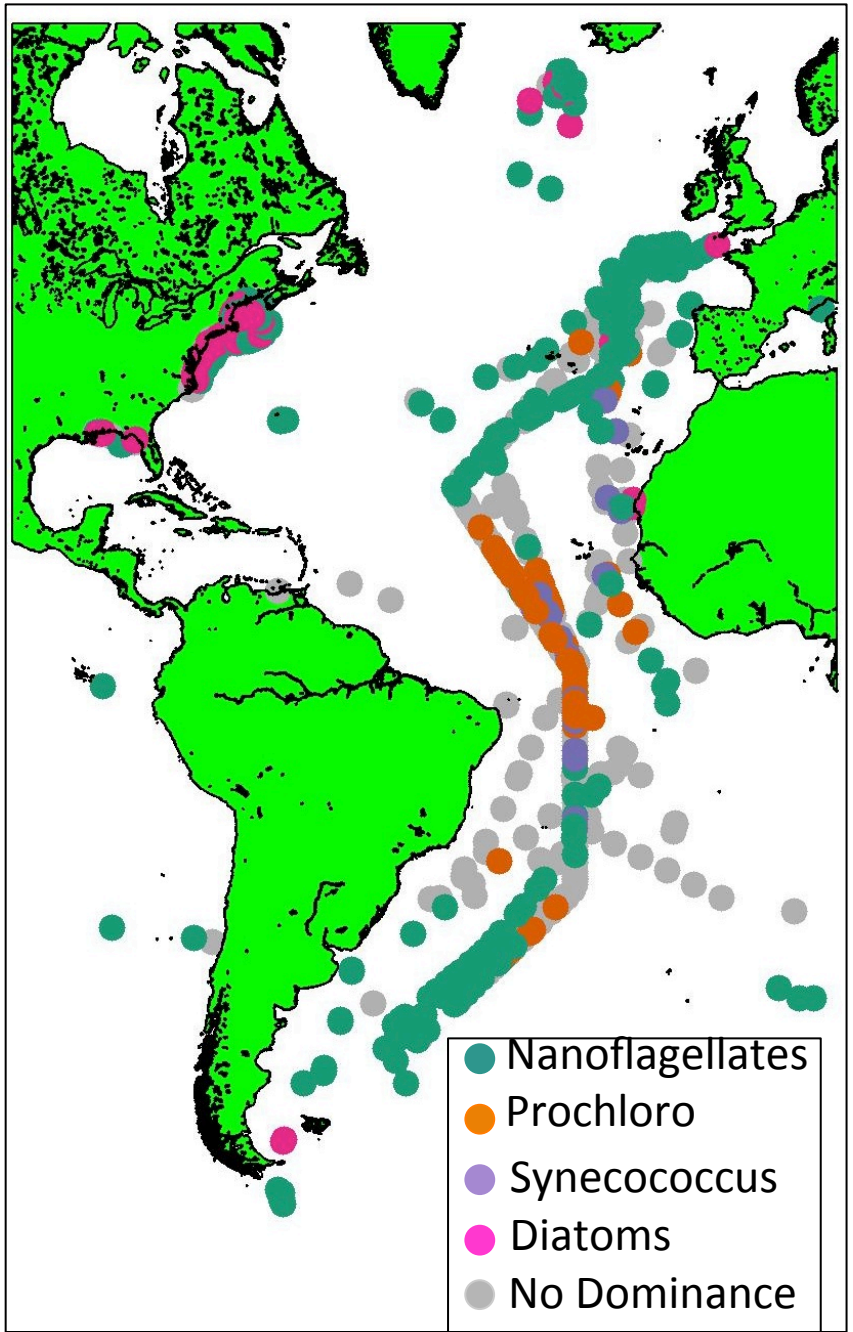
Diatoms

Synechococcus

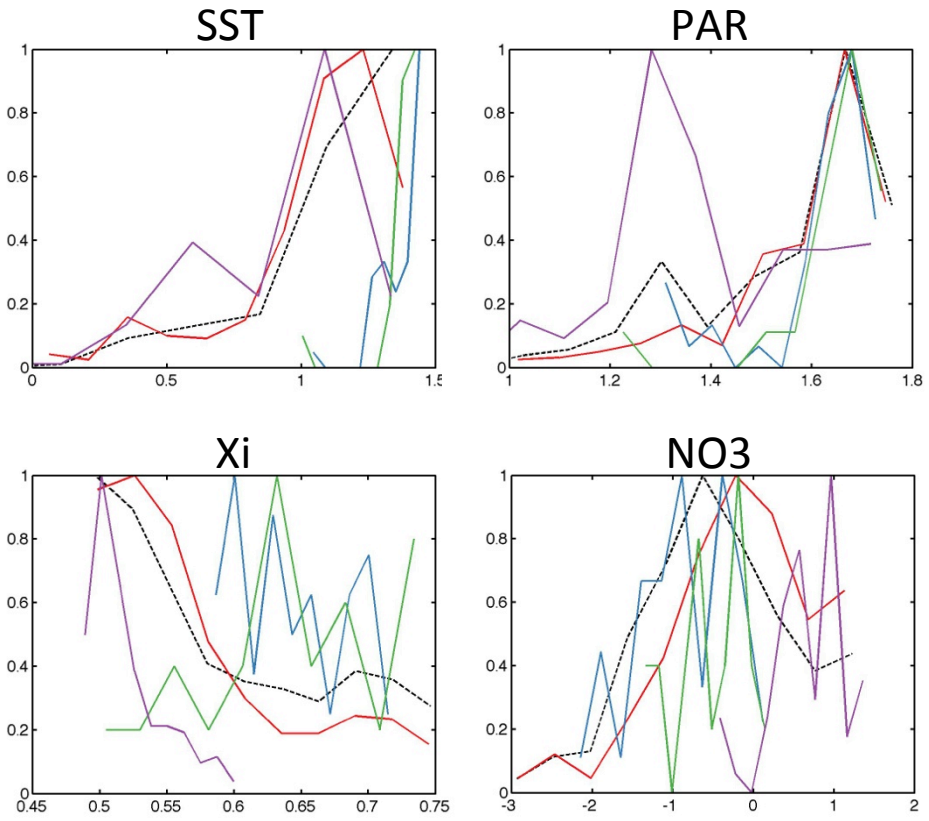
Nano flagellates

Prochloro

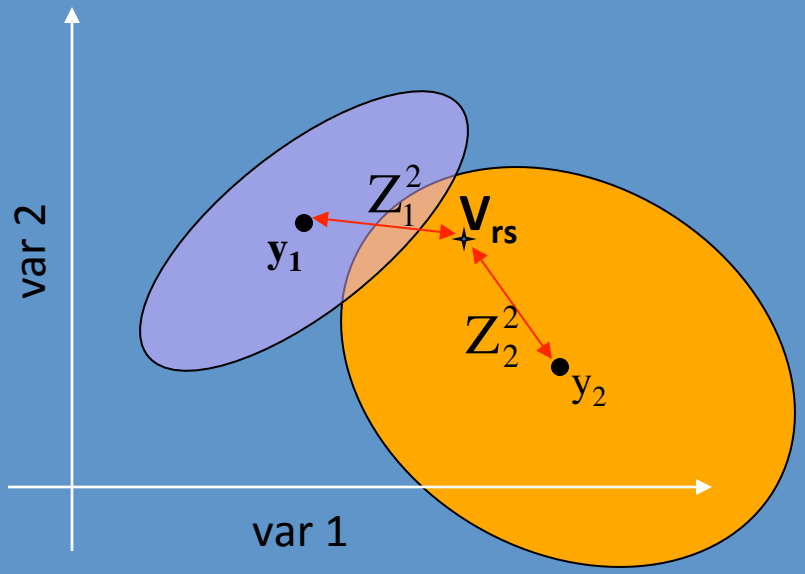
# Atlantic matchup data set




- ~800 matchup points between HPLC in situ and satellite variables.
- 340 points had a 'dominant' PFT present (~50%).
- Nanoflagellates dominated PFTs (~70%).
- Synechococcus dominant least abundant (5%).



# Statistical Model




$$Z^2 = (\mathbf{V_{rs}} - \mathbf{y}_j)^t \Sigma_j^{-1} (\mathbf{V_{rs}} - \mathbf{y}_j)$$ ⟹ Chi-square PDF

$\mathbf{V_{rs}}$ – Environmental vector

$\mathbf{y}_j$ – *j*th PFT mean vector

$\Sigma_j$ – *j*th PFT covariance matrix

# Performance matrix – 5 PFT types

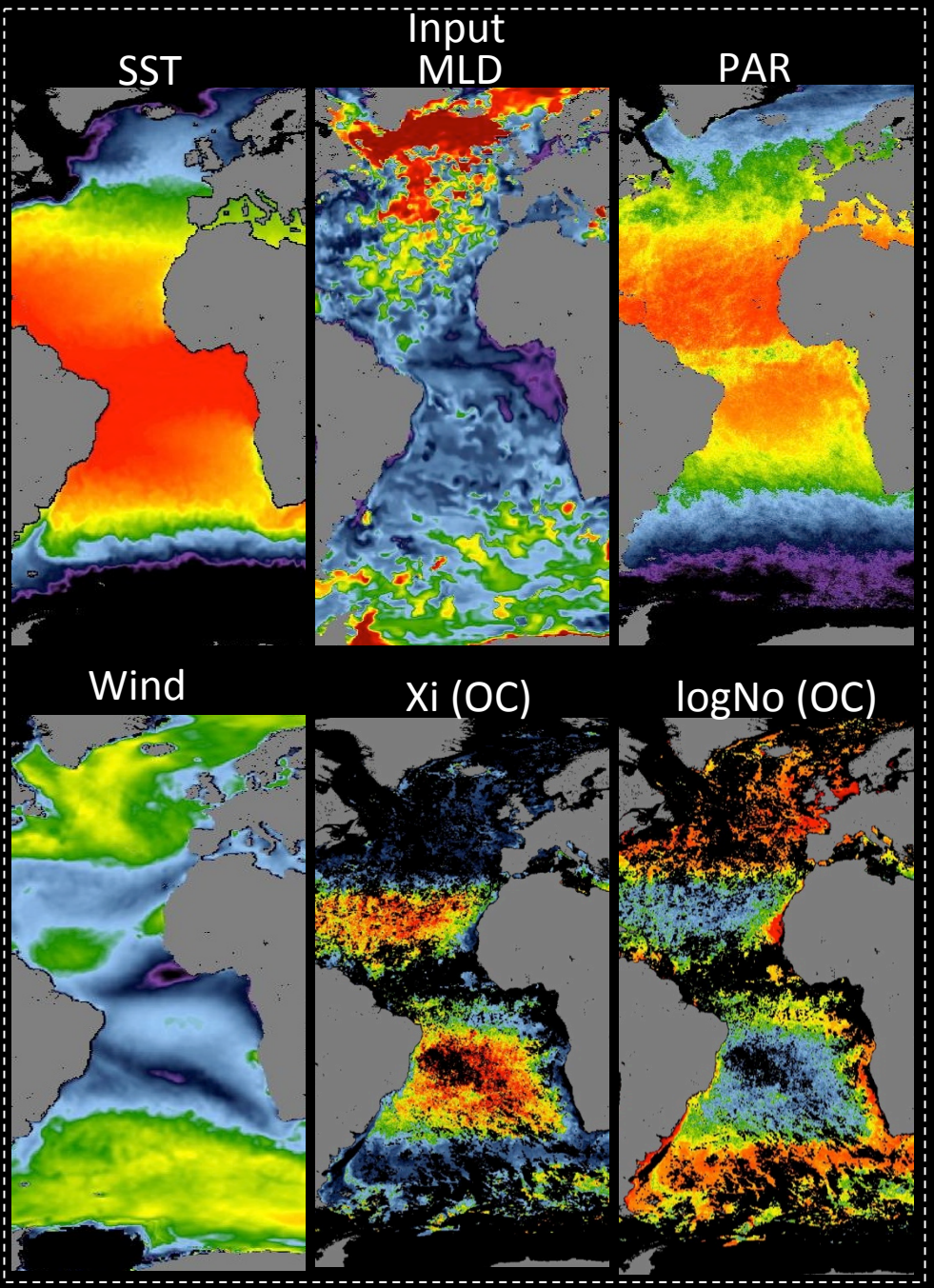
| Scenario | Training* % correct | Eval** % correct |
|---|---|---|
| 1 | 43.9 | 40.6 |
| 2 | 58.8 | 50.7 |
| 3 | 70.7 | 55.6 |
| 4 | 72.3 | 55.7 |
| 5 | 79.3 | 63.9 |
| 6 | 88.7 | 72.6 |

- Best performance with all variables combining OC & env data.
- Systematic additions of variables improved performance.

Scenario 1: PSD only
Scenario 2: Sc1 + SST
Scenario 3: Sc2 + PAR
Scenario 4: Sc3 + MLD
Scenario 5: Sc4 + wind
Scenario 6: Sc5 + nutrients

*Training Data used from 'dominant' points in pool of data (N=370)

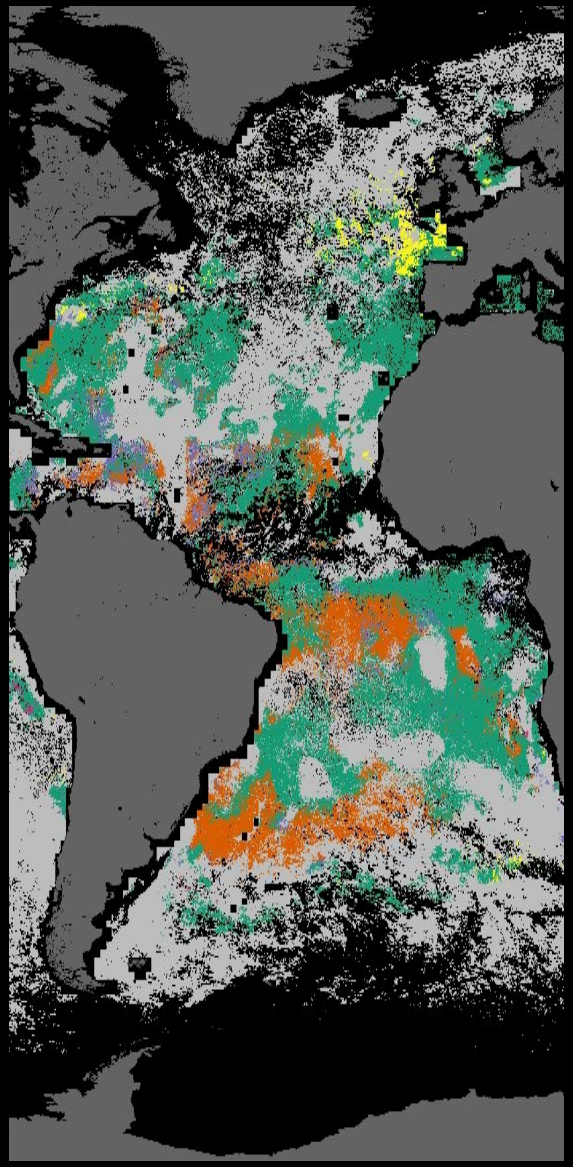
**Data not used but 'not dominant' from remaining pool of data (N=421)




April 2003

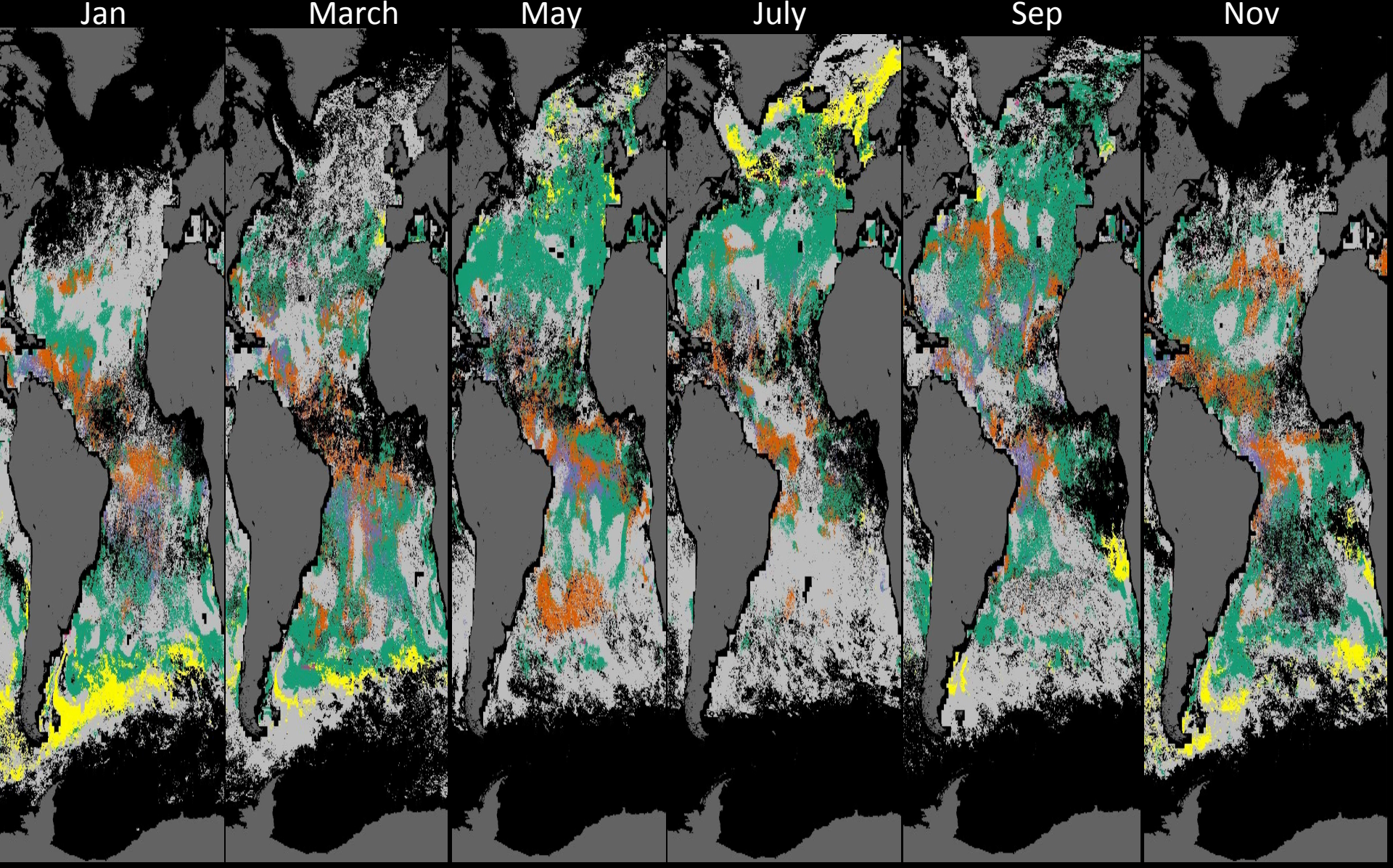
Niche model

Dominant PFT



Nanoflag Prochl Syneco Diatoms Cocco Low Membership

# 2004


Jan
March
May
July
Sep
Nov
Nanoflag
Prochl
Syneco
Diatoms
Cocco
Low Membership

# Summary

- A model was developed to predict dominant PFT groups at the oceans *surface* using particle size information from ocean color imagery combined with environmental data.
- The model was based on a 'habitat/niche' concept formed by observed relationships between identified PFT groups (from in situ HPLC) and co-located satellite variables (e.g., PAR, MLD, wind, SST and nutrients).
- Model is driven by assumptions on 1) initial Chemtax-derived phytoplankton group accuracy, 2) partitioning of these groups into PFTs, and 3) niche concept applying to broad phytoplankton groups.
- 5 PFTs were characterized in this model: Nanoflagellates, Diatoms, Coccolithophores, Prochlorococcus and Synecococcus.

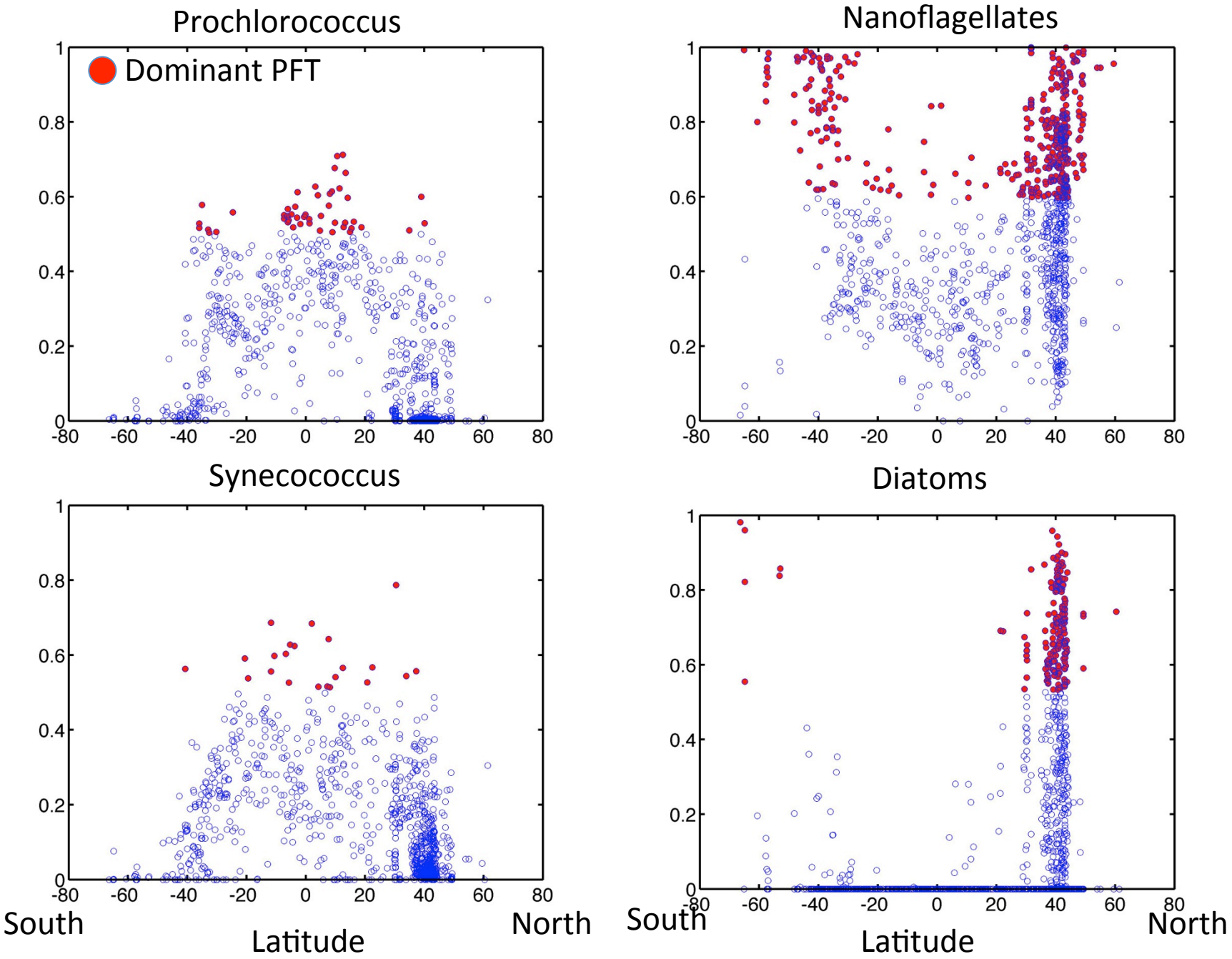
# Summary (continued)

- The model currently works predicts correct PFT 86-90% based on training set, and about 70% accuracy with a separate data set that is not totally appropriate for the model since there are no 'Dominant' points in that data set.
- Despite the large matchup data set, only 1/3 of the points were 'dominant', and more data would be beneficial for both further training, and evaluation.
- The output maps look reasonable, but its difficult to assess without other metrics to validate.

# Future Work

- Explore alternative PFT groupings.
- Utilize upcoming PSD imagery for Aqua and VIIRS (Kostadinov).
- Assess model with an appropriate validation data set.
- Utilize monthly nitrate product for Atlantic (J. Goes).

# Backup Slides


Prochlorococcus
Dominant PFT
Nanoflagellates
Synecococcus
Diatoms
South
Latitude
North
South
Latitude
North